A Qualitative Estimation of Secondary Metabolites in Selected Leafy Vegetables Cultivated in Hydroponic System – Part I

Ravikant Ghritlahre[1*]; Labya Prabhas[2]; Amia Ekka[3]; Leena Sinha[4]

School of Studies in Life Science, Pandit Ravishankar Shukla University, Raipur, Chhattisgarh, India
*Corresponding Author

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Abstract— *Leafy vegetables are important in medicine and are easily accessible, making them the most affordable source of treatment in the primary healthcare system for poor communities. Phytochemicals are plant components with specific bioactivities in animal biochemistry and metabolism. They are being extensively studied for their potential to provide health benefits. It is crucial to establish a scientific rationale to support their use in foods as potential nutritionally active components. Some of the significant phytochemicals with a variety of biological functions include alkaloids, flavonoids, phenolics, tannins, terpenoids, steroids, glycosides, and terpenes. The current investigation evaluates the phytochemical profiles of a sample of 8 leafy vegetable species cultivated in both soil-based and hydroponic growing environments. The study found that some species in both cultivation methods contain phenolics, flavonoids, alkaloids, and terpenoids. The importance of specific plant species is examined in relation to their role in ethnomedicine, and these results will be useful for further comparative studies of phytochemistry in beds and for subsequent studies on hydroponic cultivation*.

Keywords— Leafy vegetables, Phytochemicals, Secondary metabolites, Hydroponic, Ethnomedicine, Beneficial.

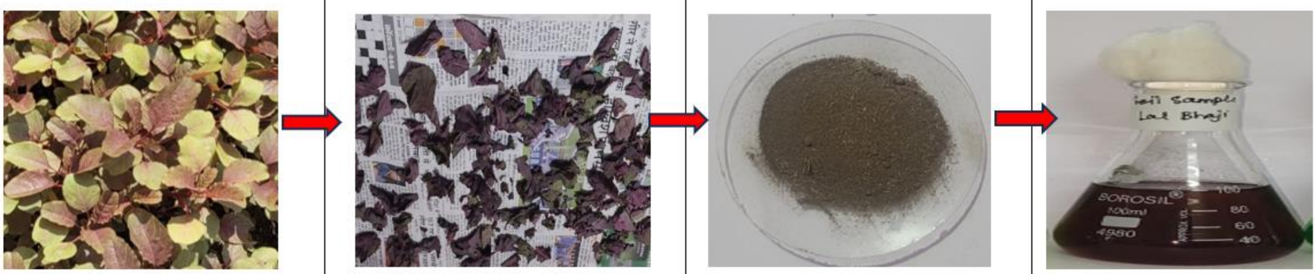
I. INTRODUCTION

Vegetables are an important component of daily meals because they are vital for supplying nutrients, preventing disease, and promoting general health. Leafy vegetables, such as amaranth and spinach, play a vital role in human nutrition. They are a rich source of vitamins, minerals, and phytochemicals, all of which are essential for maintaining good health. Natural plant merchandise was used for medicinal programs on the grounds that historic times. However, with advancements in various scientific fields, herbal medicines have been developed. Investigating regional flora as potential sources of crude extracts or chemicals with therapeutic qualities is currently gaining traction. "Medicinal plants have been studied to determine their potential to offer safe, affordable, and effective remedies for various diseases. This has led to an increased interest in creating natural remedies as alternatives to commonly used synthetic drugs. Phytochemicals are bioactive substances produced by plants metabolically, which have protective and detoxifying properties [2][23]. They are non-nutritive components that shield plants from environmental stresses and are responsible for various physiological activities. Leafy vegetables are an excellent source of beneficial microflora. Since they are relatively non-nutritive, they are an effective method of shielding probiotics from bile salt and stomach acid damage. Antimicrobial plants contain diverse bioactive secondary metabolites, such as alkaloids, terpenes, tannins, saponins, and flavonoids. Flavonoids and Alkaloids have antibacterial, antiviral, and anticancer properties. Other secondary metabolites include phenolic and polyphenolic compounds. Plant-derived chemicals have been proven to be effective in controlling diseases, and importantly, they have no adverse impacts on humans or the environment".

Phytochemicals are extracted from plant material using methods like maceration, percolation, infusion, hot continuous extraction (Soxhlet extraction), etc. Eco-friendly techniques like Ultrasound-Assisted Extraction, Microwave-Assisted Extraction, etc., are also used. The extraction procedure used a variety of solvents, including water, ethanol, methanol, acetone, ether, benzene, chloroform, etc [16][33]. The phytochemical screening of eight distinct leafy vegetable species is compared in this study, including *Raphanus sativus L.* (Mooli bhaji), *Chorchorus olitorius L.* (Chech bhaji), *Lathyrus sativus L.* (Lakhdi bhaji), *Carthamus tinctorius L*. (Kusum bhaji), *Amaranthus tricolor L*. (Lal bhaji), *Mentha piperital L*. (Peppermint), *Ipomea aquatica F*. (Karmata bhaji), *Trigonella foenum-graecum L.* (Methi bhaji). These vegetables were grown in both soil and hydroponic systems.

II. MATERIAL AND METHODS

Eight different species of leafy vegetables, namely *Raphanus sativus L*. (Mooli bhaji), *Chorchorus olitorius L.* (Chech bhaji), *Lathyrus sativus L*. (Lakhdi bhaji), *Carthamus tinctorius L*. (Kusum bhaji), *Amaranthus tricolor L*. (Lalbhaji), *Mentha piperital L*. (Peppermint), *Ipomea aquatica F*. (Karmata bhaji), *Trigonella foenum-graecum* L. (Methi bhaji) were selected for this study. The samples were cultivated in the backyard of the Life Science department in Pandit Ravishankar Shukla University, Raipur, Chhattisgarh (India) from January to April the year 2023-2024. In this experiment, we took fresh mature leaves from plants grown in soil and plants grown hydroponically. We thoroughly washed the leaves, sliced them into small pieces, and then dried them in the shade at a temperature of 25 ± 2 ºC for about 7 days. An appropriate grinder was then used to grind the dried plant fragments into a coarse powder. The powder was then stored in an airtight container in a cold, dark, and dry environment until analysis began. The plant leaf samples were extracted using methanol.100 cc of methanol was added to a flask containing 10 g of each powdered plant material, and the flask was left to stand for 48 to 72 hours. The mixture was filtered using Whatman filter paper No. 1. The resulting extracts were labeled as methanol extract and stored in sealed bottles at 5°C for future use [9].



Fresh mature leaves of the sample	Fresh Sample Cut into small pieces and dried in the shade at a temperature of 25 ± 2ºC	Dried plants processed into a coarse powder	Methanol Extract of Dried Sample

FIGURE 1. Showing the process of making Methanol extract using Dry Sample

2.1 Phytochemical Screening:

- **Test for alkaloid (Wagner's test):** Two millilitres of test sample filtrate were mixed with one or two drops of Wagner's reagent (iodine in potassium iodide) along the sides of the test tube in order to perform the alkaloid-detection test. The appearance of reddish-brown precipitates indicates the presence of an alkaloid [29].

- **Test for Flavonoids (Ferric chloride test):** Two millilitres of the filtrate from the test sample were mixed with a few drops of a 10% ferric chloride solution. The presence of flavonoids in the sample is indicated by a green precipitate at the bottom of the test tube [9].

- **Test for Phenolics (Lead acetate test):** Five millilitres of the filtrate from the test sample were mixed with three millilitres of a 10% lead acetate solution. White precipitate indicates the presence of the phenolic component in the test sample [34].

- **Test for Tannins (10% NaOH test):** In 0.4 millilitres filtrate of the test sample, 4 millilitres of 10% sodium hydroxide solution was added and shaken well. The emulsion's formation indicates that the test sample contains tannins [34].

- **Test for Terpenoids (Salkowski's test):** After adding two millilitres of chloroform to five millilitres of the test sample filtrate, the mixture is evaporated on a water bath. The liquid is then brought to a boil on a water bath with three millilitres of pure sulfuric acid added. There are terpenoids present if a grey-coloured solution is formed [9].

- **Test for Phytosterols (Sulphuric acid test):** A few drops of concentrated H_2SO_4(sulphuric acid) were added to three millilitres of filtrate. shaken thoroughly and left to stand. The red colour at the lower layer indicates the presence of phytosterol in the sample [9].

III. RESULT AND DISCUSSION

TABLE 1
SHOWING ASSESSMENT OF PHYTOCHEMICALS IN THE LEAF EXTRACT OF LEAFY VEGETABLES CULTIVATED IN SOIL AND HYDROPONIC

S.No.	Plant Species	Parameters											
		Alkaloids		Flavonoids		Phenolics		Tannins		Terpenoids		Phytosterols	
		SCP	HCP	SCP	HCP	SCP	HCP	SCP	HCP	SCP	HCP	SCP	HCP
1	*Raphanus sativus L*	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
2	*Chorchorus olitorius L.*	+ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	+ve	+ve	+ve	+ve
3	*Lathyrus sativus L.*	+ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	+ve	+ve	-ve	-ve
4	*Carthamus tinctorius L.*	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	-ve	-ve
5	*Amaranthus tricolor L.*	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
6	*Mentha arvensis*	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	+ve	+ve
7	*Ipomea aquatica F.*	+ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	+ve	+ve	-ve	-ve
8	*Trigonella foenum-graecum L.*	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve

+ve = Presence; SCP: Soil Cultivated Plant -ve = Absent; HCP: Hydroponic Cultivated Plant

Alkaloids

SCP **HCP**

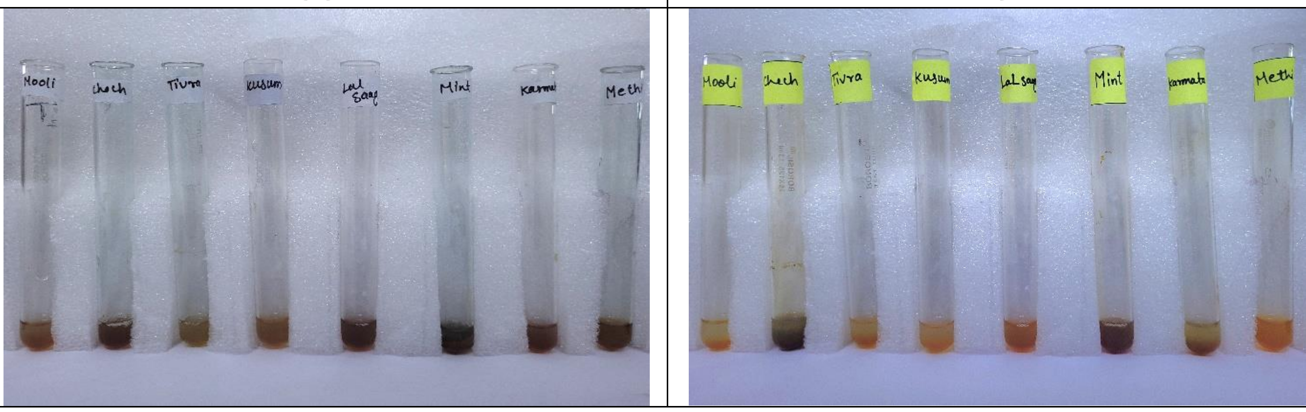


FIGURE 2. Showing the Qualitative Test of Alkaloids in SCP and HCP

Flavonoids

SCP **HCP**

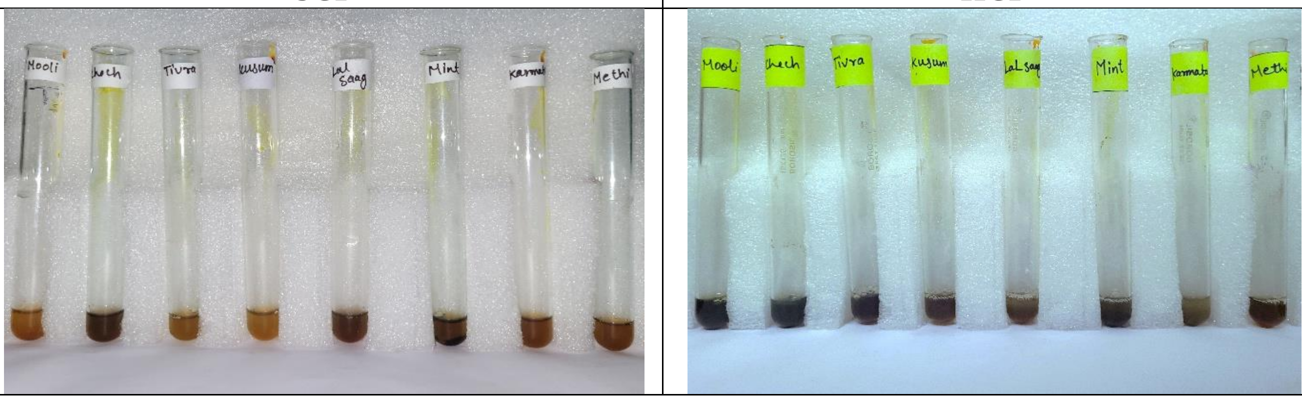
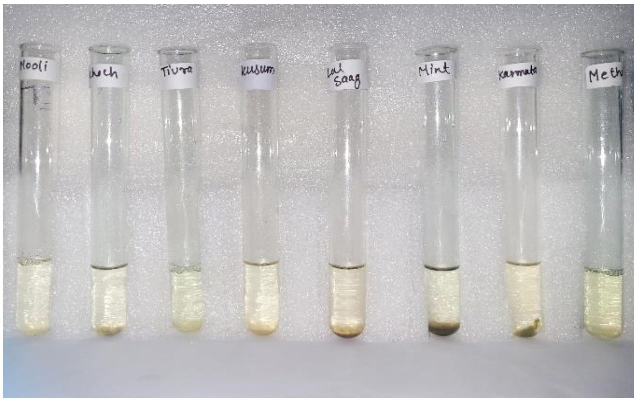


FIGURE 3. Showing the Qualitative Test of Flavonoids in SCP and HCP

Phenolics	
SCP	**HCP**



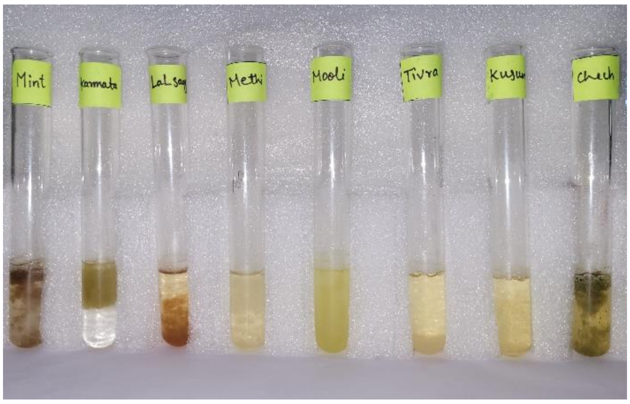
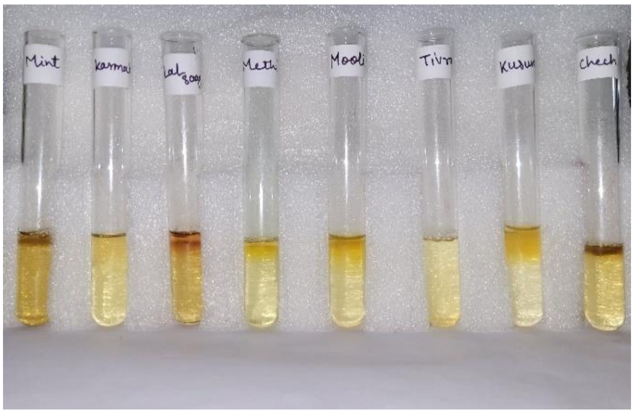


FIGURE 4. Showing the Qualitative Test of Phenolics in SCP and HCP

Tannins	
SCP	**HCP**



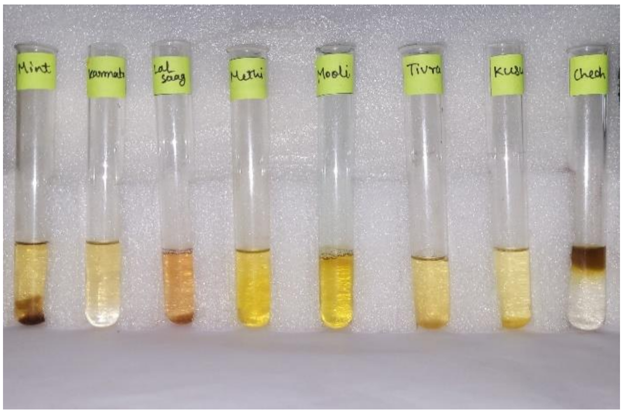
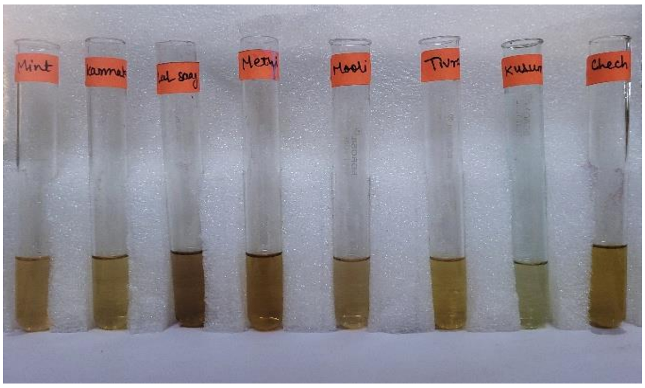


FIGURE 5. Showing the Qualitative Test of Tannins in SCP and HCP

Terpenoids	
SCP	**HCP**



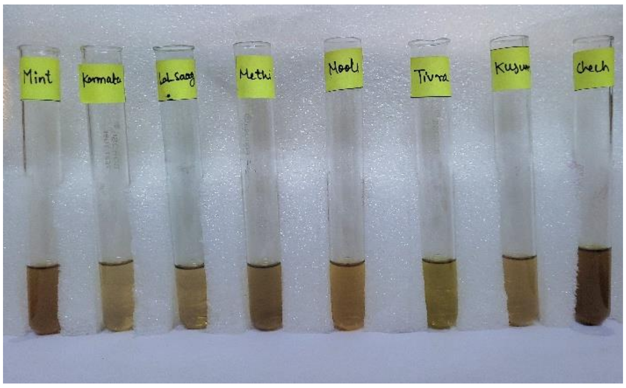


FIGURE 6. Showing the Qualitative Test of Terpenoids in SCP and HCP

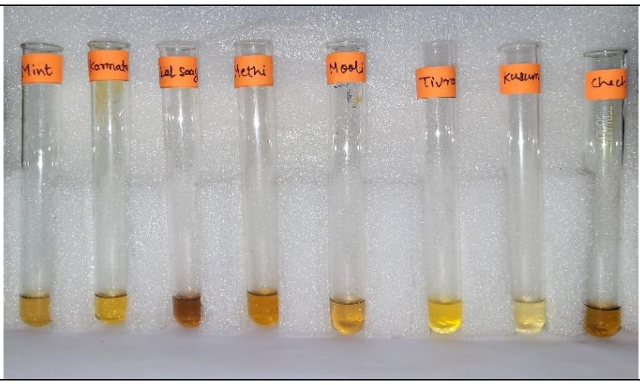
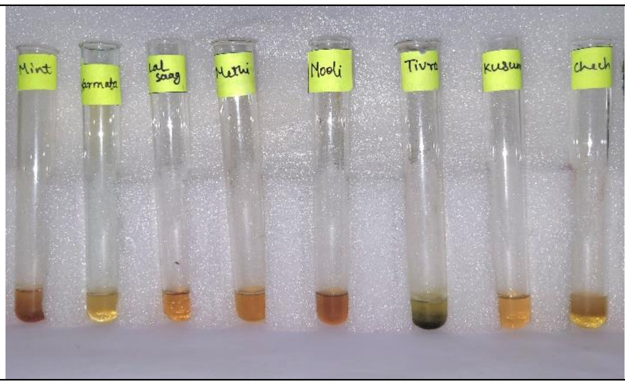
Phytosterols	
SCP	**HCP**
	

FIGURE 7. Showing the Qualitative Test of Phytosterols in SCP and HCP

The results of eight leafy vegetable species cultivated in soil and hydroponic systems are reported in Table 1. Study reveals that the presence and absence of secondary metabolites are similar in both soil-cultivated and hydroponically cultivated plants. All plant species had tannins, except *Lathyrus sativus L., Ipomea aquatica F.,* and *Chorchorus olitorius L.* Every plant species has terpenoids, except *Mentha arvensis,* and *Carthamus tinctorius L.* Phytosterols were found in all plant species except *Lathyrus sativus L., Carthamus tinctorius L., Ipomea aquatica F.*

- ***Raphanus sativus L.*** has compounds like alkaloids, flavonoids, phenols, tannins, terpenoids, and phytosterols, whether it's grown in soil or using hydroponic methods.
- ***Chorchorus olitorius L.*** has alkaloids, flavonoids, phenolics, terpenoids, and phytosterols in both soil-grown and hydroponic plants, but it does not contain tannins.
- ***Lathyrus Sativus L.*** contains alkaloids, flavonoids, phenolics, and terpenoids in both soil and hydroponic cultivation, except for tannins and phytosterols.
- ***Carthamus tinctorius L.*** has alkaloids, flavonoids, phenolics, and Tannins in both soil-grown and hydroponically grown plants, but it does not contain terpenoids and phytosterols.
- ***Amaranthus tricolor L.*** contains alkaloids, flavonoids, phenolics, tannins, terpenoids, and phytosterols in both soil and hydroponic cultivation.
- ***Mentha piperita L.*** contains various chemical compounds such as alkaloids, flavonoids, phenolics, tannins, and phytosterols in both soil-grown and hydroponic systems, except terpenoids.
- ***Ipomea aquatica F.*** contains alkaloids, flavonoids, phenolics, and terpenoids in both soil and hydroponic cultivation, except for tannins and phytosterols
- ***Trigonella foenum-graecum L.*** contains a variety of bioactive compounds such as alkaloids, flavonoids, phenolic substances, terpenoids, and phytosterols in both soil-grown and hydroponic systems, except tannins.

IV. CONCLUSION

The research compares the presence of plant chemicals in eight types of leafy vegetables grown in soil and in water-based growing systems. It evaluates the qualitative estimation of Secondary Metabolites in various species, showing similar results for both soil and hydroponically cultivated plants. This shows how hydroponics can offer better nutrient buildup and higher crop production. Hydroponic plants often have a higher level of advantageous compounds compared to plants cultivated in soil. However, it is important to consider the associated costs and the efforts required for management to achieve positive results. This analysis emphasizes the potential of hydroponics as a viable alternative to traditional soil farming, particularly in areas facing land and water scarcity.

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REFERENCES

[1] B. Neeharika, K. Patel, J. Suneetha, and B. A. Kumari, "Blanched bathua leaves: Influence on phytochemical and antioxidant properties," *Int. J. Conserv. Sci*., vol. 7, pp. 793–799, 2019.

[2] C. S. Ezeonu and C. M. Ejikeme, "Qualitative and quantitative determination of phytochemical contents of indigenous Nigerian softwoods," *New J. Sci.,* pp. 1–9, 2016.

[3] D. Sinha, S. Mukherjee, and S. Chowdhury, "Methods of extraction of phytochemicals," in *Phytochemicals*, ch. 10, 2022. doi: 10.4018/978-1-6684-7337-5.ch010.

[4] E. De Almeida Melo, J. Mancini Filho, and N. B. Guerra, "Characterization of antioxidant compounds in aqueous coriander extract (Coriandrum sativum L.)," *LWT-Food Sci. Technol*., vol. 38, no. 1, pp. 15–19, 2005.

[5] F. Beddou et al., "Potential assessment of Rumex vesicarius L. as a source of natural antioxidants and bioactive compounds," *J. Food Sci. Technol*., vol. 52, pp. 3549–3560, 2015.

[6] H. Meena, B. Ballabh, S. Arya, and M. Bala, "Evaluation of phytochemicals, antioxidant property, and effects of Cichorium intybus cultivated at foothill area of Uttarakhand on hyperglycemic rats," *Int. J. Compr. Adv. Pharmacol*., vol. 7, no. 1, pp. 54–64, 2022.

[7] H. T. Adejoke, H. Louis, O. O. Amusan, and G. Apebende, "A review on classes, extraction, purification and pharmaceutical importance of plant alkaloid," *J. Med. Chem. Sci*., vol. 2, no. 4, pp. 130–139, 2019.

[8] J. Parekh and S. Chanda, "Phytochemicals screening of some plants from western region of India," *Plant Arch*., vol. 8, pp. 657–662, 2008.

[9] J. R. Shaikh and M. Patil, "Qualitative tests for preliminary phytochemical screening: An overview," *Int. J. Chem. Stud*., vol. 8, no. 2, pp. 603–608, 2020.

[10] K. Patel and M. Vakilwala, "Phytochemical study and bioactivity of solvent extracts on Coriandrum sativum," *Int. J. Adv. Res. Biol. Sci*., vol. 3, no. 5, pp. 193–199, 2016.

[11] K. Patil and A. P. Jain, "Extraction, qualitative and quantitative determination of secondary metabolites of Corchorus olitorius," *Chem. Reagents*, 2017.

[12] Khanal, "Phytochemical and antibacterial analysis of Mentha piperita (Peppermint)," Doctoral dissertation, 2020.

[13] M. G. Rasul, "Conventional extraction methods use in medicinal plants, their advantages and disadvantages," *Int. J. Basic Sci. Appl. Comput*., vol. 2, no. 6, pp. 10–14, 2018.

[14] M. Madhu et al., "Quantitative phytochemical analysis of selected medicinal plant species by using various organic solvents*," J. Pharmacogn. Phytochem*., vol. 5, no. 2, pp. 25–29, 2016.

[15] M. Manvar and T. Desai, "Phytochemical and pharmacological profile of Ipomoea aquatica," *Indian J. Med. Sci.,* vol. 67, no. 3–4, p. 49, 2013.

[16] N. N. Azwinda, "A review on the extraction method used in medicinal plants, principle, strength and limitation," *Medicinal and Aromatic Plants*, vol. 4, no. 3, pp. 1–6, 2015.

[17] N. Sharma, V. Kumar, and N. Gupta, "Phytochemical analysis, antimicrobial and antioxidant activity of methanolic extract of Cuscuta reflexa stem and its fractions," *Vegetos*, vol. 34, pp. 876–881, 2021.

[18] O. S. Kumari, N. B. Rao, and R. G. Gajula, "Phytochemical analysis and anti-microbial activity of Trigonella foenum-graecum (Methi seeds)," Diabetes, vol. 1, no. 19, p. 4, 2016.

[19] P. Diwan, R. K. Naik, and A. Gautam, "Studies on the status and opportunity of leafy vegetable crop harvesting in Chhattisgarh," *Biol. Forum – Int. J.,* vol. 13, no. 4, pp. 837–841, 2021.

[20] R. Abubakar and M. Haque, "Preparation of medicinal plants: Basic extraction and fractionation procedures for experimental purposes," *J. Pharm. Bioallied Sci*., vol. 12, no. 1, pp. 1–10, 2020. doi: 10.4103/jpbs.JPBS_175_19.

[21] R. N. S. Yadav and M. Agarwala, "Phytochemical analysis of some medicinal plants," *J. Phytol*., vol. 3, no. 12, 2011.

[22] R. Routrayi, M. Kar, and R. K. Sahu, "Evaluation of antioxidant potential in selected leafy vegetables of Odisha, India," *Int. J. Pharm. Pharm. Sci*., vol. 5, pp. 232–235, 2013.

[23] R. Sheel, K. Nisha, and J. Kumar, "Preliminary phytochemical screening of methanolic extract of Clerodendron infortunatum," *IOSR J. Appl. Chem*., vol. 7, no. 1, pp. 10–13, 2014.

[24] S. A. Ahmed, S. Hanif, and T. Iftkhar, "Phytochemical profiling with antioxidant and antimicrobial screening of Amaranthus viridis L. leaf and seed extracts," *Open J. Med. Microbiol*., vol. 3, no. 3, pp. 164–171, 2013.

[25] S. A. Audu, I. Mohammad, and H. A. Kaita, "Phytochemical screening of the leaves of Lophira lanceolata (Ochanaceae)," *Life Sci. J*., vol. 4, no. 4, pp. 75–79, 2007.

[26] S. Alok et al., "Plant profile, phytochemistry and pharmacology of Asparagus racemosus (Shatavari): A review," *Asian Pac. J. Trop*. Dis., vol. 3, no. 3, pp. 242–251, 2013. doi: 10.1016/s2222-1808(13)60049-3.

[27] S. Badyal, H. Singh, A. K. Yadav, S. Sharma, and I. Bhushan, "Plant secondary metabolites and their uses," *Plant Arch*., vol. 20, no. 2, pp. 3336–3340, 2020.

[28] S. Dayani and M. R. Sabzalian, "Production of secondary metabolites in medicinal plants through hydroponic systems," in Controlled Environmental Agriculture, *Nova Science*, Inc., New York, pp. 33–53, 2017.

[29] S. Kaliyaperumal and M. Radhika, "Study of phytochemical analysis and antioxidant activity of Spinach oleracea L. plant leaves," *Pharma Innov. J*., vol. 9, no. 7, pp. 1–4, 2020.

[30] S. Nathenial et al., "Phytochemical study of acetone solvent extract of Coriandrum sativum," *J. Pharmacogn. Phytochem.,* vol. 8, no. 6, pp. 136–140, 2019.

[31] S. S. Mulay, "Pharmacognostic account and phytochemical studies of Hibiscus sabdariffa Linn," *World J. Pharm. Res*., vol. 7, no. 14, pp. 978–985, 2018.

[32] Singh and Ram Avtar Sharma, *Secondary Metabolites of Medicinal Plants*. John Wiley & Sons, 2020.

[33] T. Dhanani, S. Shah, N. A. Gajbhiye, and S. Kumar, "Effect of extraction methods on yield, phytochemical constituents and antioxidant activity of Withania somnifera," *Arabian Journal of Chemistry,* vol. 10, pp. 1193–1199, 2017.

[34] V. Singh and R. Kumar, "Study of phytochemical analysis and antioxidant activity of Allium sativum of Bundelkhand region," *Int. J. Life-Sci. Sci. Res*., vol. 3, no. 6, pp. 1451–1458, 2017.

[35] V. Tamrakar, D. Arora, and C. Arora, "Phytochemical screening of leafy vegetables of Chhattisgarh state," *Ann. Hortic*., vol. 10, no. 2, pp. 202–206, 2017.